INTRASPECIFIC HABITAT SEGREGATION OF SMALLMOUTH BASS IN THE BUFFALO RIVER, ARKANSAS

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science

By

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Introduction

There are numerous studies of habitat use by smallmouth bass (Micropterus dolomieu), but most have concentrated on adults and juveniles (Edwards et al. 1983; Probst et al. 1984; Rankin 1986; McClendon and Rabeni 1987; Todd and Rabeni 1989). Miller (1979) stressed that understanding the phenology of fishes was essential for predictive ecological modeling and management of aquatic ecosystems, and Moyle et al. (1982) hypothesized that in stream fish assemblages with low diversity, juvenile fishes are often ecologically distinct from adults. Orth (1987) stressed that size-related differences in habitat needs and limiting factors must be identified and incorporated into assessments. Thus, consideration of habitat needs at all life stages should be important to management of smallmouth bass.

Recent studies of habitat use by individual species or by species assemblages of stream fish have shown differences in habitat use by different size/age groups of various species (Matheson and Brooks 1983; Moyle and Baltz 1985; Moyle and Vondracek 1985; Gorman 1987; Grossman et al. 1987; Baltz et al. 1991). These studies have found intraspecific habitat segregation among both cold and warmwater species.

Suitable habitat may be most important during the critical first year for smallmouth bass, when the small size of the young results in a greater susceptibility to predators and a more limited size range of prey. Both can influence habitat use by young.

Three studies in eastern U.S. streams have quantified intraspecific habitat segregation by smallmouth bass (Bain et al. 1988; Leonard and Orth 1988; Lobb and Orth 1991). In the West River, Vermont, smallmouth bass <=100 mm TL specialized in microhabitats characterized by shallow water, slow currents and coarse substrates. Smallmouth bass >100 mm TL used available habitats broadly, therefore overlapping all other species and size classes including conspecific young (Bain et al. 1988). In tributaries of the James River, Virginia, young (<100 mm) and juvenile (100-200 mm) smallmouth bass used shallower water and slower flows than adults (>200 mm), while adults utilized finer grained substrates, and were closely associated with cover objects (Leonard and Orth 1988). In the New River, West Virginia, young smallmouth bass preferred shallow water habitats with slow to moderate currents along the shoreline, while juveniles and adults were habitat generalists, but preferred snag habitats and avoided shallow water (Lobb and Orth 1991).

Fish populations may be adapted to local conditions and species with which they have evolved. Feminella and Matthews (1984) found different populations of <u>Etheostoma spectabile</u> to differ in physiochemical tolerances. It may follow that macro- and microhabitat use differs on a local scale. A recent survey conducted by Reiser et al. (1989)

identified the need for more species habitat information and preference curves developed for local areas. Another area of concern was the need to validate and test the existing Habitat Suitability Index (HSI) models and to modify them to local conditions (Reiser et al. 1989). The HSI models for young smallmouth bass are based on limited empirical data (Edwards et al. 1983).

Until now there have been no attempts to quantify intraspecific habitat segregation of smallmouth bass in an Ozark stream. The fish species assemblage of the Buffalo River differs from eastern and upper midwest streams (See Appendix 1 for a list of Buffalo River species) as do the physical and chemical characteristics of the Buffalo River (Babcock et al. 1976; Petersen 1992). Thus, habitat use by smallmouth bass in this stream may also differ from habitat use in eastern and upper midwest streams.

The objectives of this study were to 1) investigate possible habitat segregation, both at the macro- and microhabitat levels, between young-of-the-year (young) and adult smallmouth bass in the Buffalo River, Arkansas and 2) compare habitat use by adult and young smallmouth bass in the Buffalo River with that in streams from other areas of the country.

Study Area

The Buffalo River is a tributary of the White River in northcentral Arkansas (Fig. 1). Originating in the Boston Mountains of Newton County, Arkansas, it flows eastward for 238 kilometers, passing through the Springfield and Salem Plateaus of the Interior Highlands Province (Croneis 1930). The drainage basin encompasses 3465 km^2 (Babcock et al. 1976). Stream gradients range from 2.09 m/km in the upper study area to 0.57 m/km in the lower river. Mean annual discharge in the middle reach of the river is 25.8 m^3/s and ranges from 0.04 to 555.0 m^3/s (USGS 1988).

The Buffalo River is a free-flowing, relatively pristine Ozark stream which received National River status in 1972. It should be a model smallmouth bass stream, lying within the native range of this species and having clear, cool water, riffle-pool morphology, and substrate consisting largely of gravel, cobble, and boulders (Coble 1975). Substrates are predominantly chert. Samples were taken from the headwaters down to the lower river, near its confluence with the White River (Fig. 2). Extreme headwater reaches were not sampled due to limited habitat available to smallmouth bass.

Figure 1.-The Buffalo River, northcentral Arkansas.

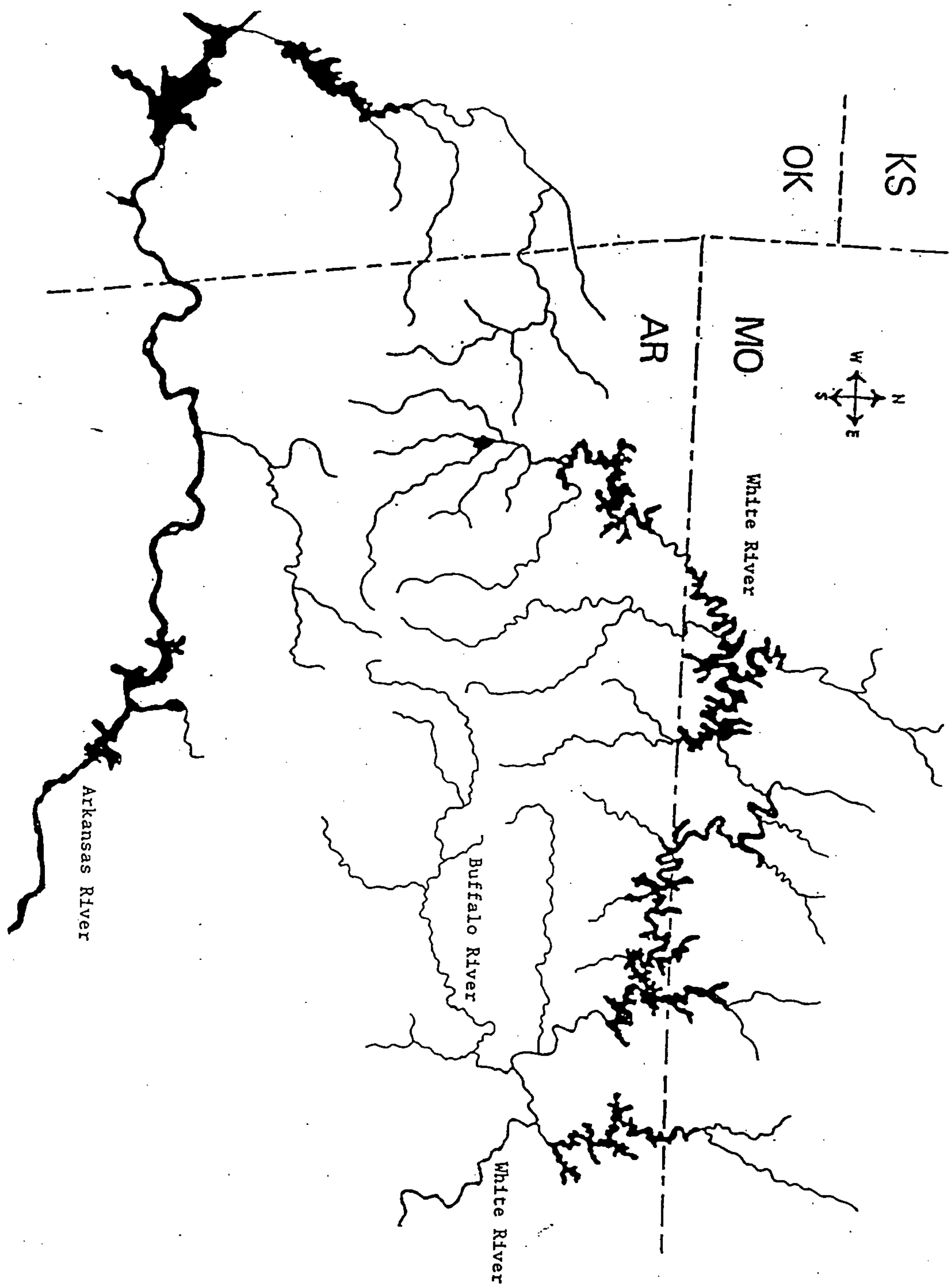
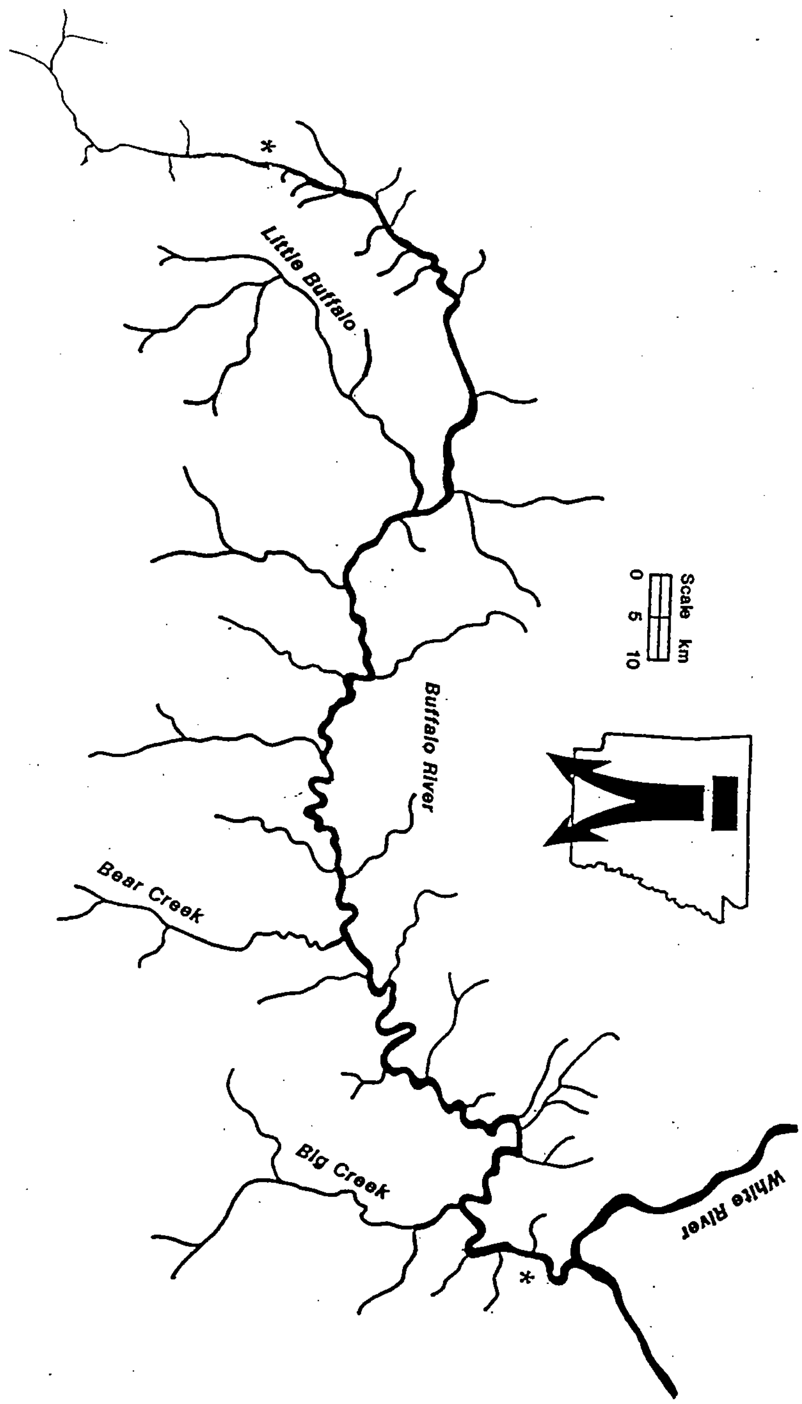

KS
OK
MO
AR
W
N
E
S
White River
Arkansas River
Buffalo River
White River

Figure 2.-Section (between asterisks) of Buffalo River sampled with snorkel transects, Summer 1991.


Little Buffalo
Buffalo River
Bear Creek
Big Creek
White River
Scale km
0 5 10

Methods

Transects.-Habitat use data were collected while snorkeling along underwater transects (approximately 2m wide) in both runs and pools (Brock 1954; Decker 1989; Dibble 1991). Visibility was always greater than 1 m and usually greater than 3 m. Pools were defined as relatively deep (generally >1 m) stretches of stream with relatively slow current velocities. Runs were defined as shallower (generally <1 m) stretches of stream with relatively fast flows but little surface turbulence; or as transition zones between pools and riffles (modified from Helm 1985 and Beschta and Platts 1986). Because there existed substantial microhabitat variation within pools and runs, transects were run in an "S" or zig-zag pattern (generally in an upstream direction) for the entire length of each pool or run. Thus all microhabitats were sampled effectively.

A total of 32 pool transects and 29 run transects were sampled between 15 June and 20 August 1991. Usually, four transects of each type were run each week, for three weeks each month. Pools and runs could not be chosen randomly due to logistical constraints. However, no pool or run was sampled more than once, thus avoiding pseudoreplication (Hurlbert 1984).

Smallmouth bass are known to be more active during periods near sunrise and soon after sunset (Emery 1973;

Reynolds and Casterlin 1976; Todd and Rabeni 1989). I accounted for this factor by considering 0500 h to 0900 h and 1700 h to 2100 h to be low light level time periods and 0900 h to 1700 h to be a high light level time period. Thirteen pool and twelve run transects were conducted during low light level periods, and eighteen pool and seventeen run transects were conducted during high light level periods.

Habitat Variable Measurements.-For each smallmouth bass encountered, I recorded the following habitat variables: substrate composition and cover type, estimated focal point depth (distance from the fish to the stream bed; to nearest 10 cm), depth of water (to nearest 0.33 m), and size of the fish. Buffalo River populations of smallmouth bass reach a maximum size of < 109 mm in their first year (Kilambi et al. 1977), and young were easily recognized by their relatively small size throughout the summer. All other sizes were classified as adults. Substrate variable sizes were based on a modified Wentworth scale (Bovee and Millhouse 1978) and were visually estimated in a 0.5 m diameter area beneath the focal point of each fish. These variables included bedrock, sand/silt, gravel, cobble, and boulders. When more than one substrate variable occurred, the most common (primary) and second most common (secondary) substrates were recorded. Cover variables included filamentous algae (which often occurred as dense clouds on the substrate), boulders, snags (woody debris including trees, rootwads, logs and branches), vegetation (aquatic macrophytes) and undercut banks. Any cover variable within 1 m of the focal point of the fish was recorded. Data were recorded on waterproof sheets.

Effects of Diver on Fish Behavior.-As with any sampling technique, there were potential biases with sampling fish using snorkel transects. Fish that swam swiftly away were not recorded, on the assumption that I could have frightened them before recording an accurate microhabitat location. Some fish simply oriented toward me, but when this did not appear to affect their original location, they were treated as normal observations. For fish that were moving but apparently not in response to my presence, habitat variables were recorded where the fish was first observed.

Small fish can also conceal themselves from view more easily than larger fish. I made every attempt to adequately sample potential sources of cover for both young and adult fish and am confident that the most important microhabitats were sampled effectively. Young typically did not seek cover in my presence.

Statistical Analysis.-All statistical analyses were done separately for pool and run samples. The categorical habitat variables were analyzed with logistic regression models, available through the CATMOD procedure in SAS (SAS

1989). Logistic regression uses data in the form of one or more explanatory (independent) variables and a response (dependent) variable. Unlike simple linear regression, in which the response variable is a continuous variable, the response variable in logistic regression is binary, having only the value of 1 (=an event), or 0 (=a non-event). Thus, the logistic regression model is built with those n independent variables which are significant in discriminating between an event and non-event. Each unique combination of variable levels observed was then categorized as a separate population and the probability of an event for each population was estimated by

(1) $P=e^{X} /1+e^{X}$

where

(2) $X=b_0+b_1v_1...+b_nv_n$

with b_0 being the intercept constant, b_1-b_n the maximum likelihood estimates, and v_1-v_n the n independent variables. A probability of near 1.0 (exactly 1.0 is theoretically not possible with logistic regression models) would indicate that, given that particular population, there would be a nearly 100% chance of an event occurring. A probability of near 0 would indicate a very small chance of an event occurring-i.e. near 100% chance of a non-event. A probability of 0.5 would indicate equal chances of an event or non-event.

The analysis also produces a test statistic (which has an approximate Chi Square distribution), used to test the fit of the model to the actual data. A small value of this statistic (high p-value) means a good fit to the data and a large value (low p-value) indicates a poor fit to the data (Agresti 1990, pages 94-97). A poor fit would imply that perhaps the sample size was too small or that other variables affect the probability of an event, which were not included in model selection.

For this study, the response variable was age, with any observation of a young smallmouth bass defined as an event, and any observation of an adult smallmouth bass defined as a non-event. Therefore, the probability of an event (occurrence of a young)=P and the probability of a non-event (occurrence of an adult)=1-P. Because the same pool or run was never sampled more than once, responses among transects were assumed independent.

Explanatory variables which fell under the general heading of substrate types included bedrock (BR), sand/silt (SASI), gravel (GR), cobble (CBL), and boulders (BLD). Each of these variables had three possible levels (values): primary substrate, secondary substrate, or absent. Explanatory variables falling under the general heading of cover types included filamentous algae (ALG), boulders (BDCOV), snags (SNAG), undercut banks (UCB) and aquatic macrophytes (VEG). Each of these variables had only two possible levels for each observation: absent or present.

Another variable, DEPTH, had 7 possible levels, representing 0.33 m intervals: 0 to 0.33 m, 0.33 to 0.67 m, and so on with the last level including all depths greater than 2 m. A final variable LIGHT (light level), had a value of 'low' for observations recorded before 0900 h or after 1700 h and 'high' for those recorded between 0900 h and 1700 h.

Initially, all habitat variables and interactions were entered into the model, but because most interactions contained too few observations to analyze, they were subsequently left out of the model. Individual variables which were not significant at the 0.05 level at discriminating between an event and non-event were also left out of the model in subsequent runs. The remaining significant variables then made up the model and the unique populations were determined. Since each population was made up of a different combination of habitat variable levels, the populations can be thought of as different microhabitats. A good model would fit the data and could accurately predict the probability of an event for each specific microhabitat.

A high observed proportion of events for any given microhabitat, say $P \geq 0.70$, would imply that mainly young smallmouth bass were found in that microhabitat. A low observed proportion of events for a given microhabitat, say $P \leq 0.30$, would imply that young smallmouth bass were typically not found in that microhabitat, but adults were.

Either of these scenarios would be evidence of habitat segregation at the microhabitat level. Microhabitats with observed proportions between 0.30 and 0.70 would imply that young and adults used them equally (i.e. there was overlap in the use of these microhabitats between young and adults). Thus, rather than producing just an index of habitat overlap (e.g. Pianka 1973), results from logistic regression analysis would show specific microhabitats where segregation or overlap occurred.

The model would also reveal which levels of the significant variables were important in determining an event, thus these habitat variables could be deemed important to young smallmouth bass. If no habitat variables were shown by the analysis to be significant at discriminating between an event and non-event, there would not be evidence of habitat segregation and thus we might conclude that extensive habitat overlap exists in the Buffalo River. Or, there may be other variables, which were not tested, which may affect habitat segregation.

One variable, focal point depth (FPD), was not recorded for every smallmouth bass observation. Because the CATMOD procedure will ignore any observation with missing data, this variable was not entered into the model to prevent losing information on the other variables. Checks on the assumptions for ANOVA showed that the data for this variable were not normally distributed and had unequal variances. A log transformation did not improve the data to meet these assumptions. Therefore, a Kruskal-Wallis non-parametric test was used to test for a difference in FPD measurements between young and adult smallmouth bass.

Results

Macrohabitat Distribution

Eight hundred fifty three smallmouth bass were sampled in pools and runs combined. This included 296 young in pools, 112 young in runs, 250 adults in pools and 195 adults in runs. This indicates that pools and runs are important macrohabitats for both young and adults. Young were observed disproportionately more often than adults in pools while adults were observed disproportionately more often in runs (Chi square=24.8, 1 d.f., $p<.001$). The pattern was similar during high (Chi square=10.0, 1 d.f., $p=.002$) and low (Chi square=10.7, 1 d.f., $p=.001$) light periods.

Microhabitat Use-Pools

In pools, five variables were significant in discriminating between the presence of young and adults (Table 1). Smallmouth bass were observed in 58 different kinds of microhabitats, based on combinations of the

Table 1.-Variables entered into the logistic regression model, and the variables significant in discriminating between the presence of young and adult smallmouth bass. Significant variables are indicated by their respective levels[a] that give the highest probability of an event (young) and non-event (adult), as predicted by the model.

	Levels giving the highest probability of occurrence of a young		Levels giving the highest probability of occurrence of an adult	
Variables Entered Into Model	Pools	Runs	Pools	Runs
Bedrock (BR)	-	2^{0}	-	1^{0}
Sand/Silt (SASI)	-	A	-	1^{0}
Gravel (GR)	-	A	-	1^{0}
Cobble (CBL)	2^{0}	-	A	-
Boulder (BLD)	-	-	-	-
Algae (ALG)	-	-	-	-
Boulder Cover (BDCOV)	-	A	-	P
Snags (SNAG)	-	-	-	-
Undercut Banks (UCB)	A	-	P	-
Macrophytes (VEG)	P	P	A	A

Table 1.-Cont'd

DEPTH	1	-	7	-
LIGHT	HIGH	HIGH	LOW	LOW

[a] For variable levels: 1°=primary substrate, 2°=secondary substrate, A=absent, P=present, 1=0 to 0.33 m, 7= >2 m, HIGH=0900 to 1700 h, LOW=0500 to 0900 h and 1700 to 2100 h.

different levels of these variables. The model producing the highest probability of occurrence of young smallmouth bass in pools was:

$$X = .3704(\text{when CBL}=2^\circ \text{ substrate}) + .5700(\text{when VEG}=\text{Present}) + .6981(\text{when UB}=\text{Absent}) + .6994(\text{when DEPTH}=0\text{-}0.33 \text{ m}) + .3655(\text{when LIGHT}=\text{High})$$

giving P=.9372

Therefore, the model predicts that 94% of the smallmouth bass observed during high light level periods in microhabitats consisting of cobble as a secondary substrate, with aquatic macrophytes present and undercut banks absent, in depths $\leq$ 0.33 m, would be young fish. The model producing the highest probability of occurrence of adult smallmouth bass in pools was:

$$X = -.3425(\text{when CBL}=\text{Absent}) - .5700(\text{when VEG}=\text{Absent}) - .6981(\text{when UB}=\text{Present}) - 1.3084(\text{when DEPTH}= >2 \text{ m}) - .3655(\text{when LIGHT}=\text{Low})$$

giving P=.0361

This model predicts that 96% (1-P) of the smallmouth bass observed during low light level periods in microhabitats where cobble and aquatic vegetation are absent, and undercut banks are present, in depths >2 m, will be adult fish.

Many of the 58 microhabitats sampled had either high or low proportions of events, but less than 10 observations. Five of the microhabitats which were observed 10 or more times had high (P>=0.7) and six had low (P<=0.3) proportions (probabilities) of events, indicating microhabitat segregation (Table 2). During high light levels, microhabitats characterized by cobble substrates, a mid range of depths, and an absence of aquatic macrophytes and undercut banks, were occupied mainly by young (Table 2). Three of these microhabitats also had a high observed proportion of young during low light levels, but less than ten observations occurred for two of them. The only microhabitat which had a high proportion of young but lacked a cobble substrate, had a very low proportion of young when light levels were low. Fifty eight observations occurred for this microhabitat during high light levels, more than any other in pools (Table 2).

During both high and low light level periods, microhabitats which lacked cobble, aquatic macrophytes, and undercut banks, with depths ranging from 0.67 m to >2 m, were occupied mainly by adults. Only one microhabitat occupied mainly by adults had a cobble substrate (Table 2). No microhabitats were occupied by either young or adults exclusively.

Predicted proportions of young (from the logistic model) were often in close agreement with observed proportions for microhabitats with ten or more observations (Table 2). However, the model did not fit the data well (Chi square=94.01, 47 d.f., p=.0001 for lack of fit). This

Table 2.-The predicted (based on the logistic regression models) and observed proportions of young smallmouth bass in all microhabitats with ≥ ten observations.

	Pool Microhabitats[a]					Observed proportion of young	Predicted proportion of young
N	CBL	VEG	UCB	DEPTH[b]	LIGHT		
13	2°	A	A	3	HIGH	.92	.67
58	A	A	A	4	HIGH	.81	.63
21	2°	A	A	5	HIGH	.76	.75
15	1°	A	A	4	HIGH	.73	.70
15	2°	A	A	3	LOW	.73	.49
13	1°	A	A	5	HIGH	.69	.66
31	A	A	A	5	HIGH	.68	.59
30	A	A	A	2	HIGH	.60	.51
22	2°	A	A	2	HIGH	.59	.68
21	1°	A	A	2	HIGH	.57	.59
14	1°	A	A	3	HIGH	.57	.58
13	A	A	A	6	HIGH	.54	.61
15	A	A	A	3	LOW	.53	.32
21	2°	A	A	4	HIGH	.48	.78
11	2°	A	A	2	LOW	.45	.51
14	A	A	A	6	LOW	.36	.43

Table 2.-Cont'd

38	A	A	A	3	HIGH	.29	.50
14	1°	A	A	3	LOW	.29	.40
13	A	A	A	7	HIGH	.23	.24
18	A	A	A	5	LOW	.22	.41
15	A	A	A	4	LOW	.13	.45
10	A	A	A	7	LOW	.10	.13

Run Microhabitats

N	BR	SASI	GR	BDCOV	VEG	LIGHT		
30	A	A	2°	A	A	HIGH	.63	.58
16	A	A	A	P	A	HIGH	.56	.66
11	A	1°	A	A	A	HIGH	.55	.54
46	A	A	1°	A	A	HIGH	.46	.39
45	A	A	2°	A	A	LOW	.29	.33
11	A	1°	2°	A	A	HIGH	.18	.24
36	A	A	1°	A	A	LOW	.17	.18
22	A	2°	1°	A	A	LOW	.14	.12
13	A	A	1°	P	A	HIGH	.08	.19

[a] For variables and variable levels: BR=bedrock, BDCOV=boulder cover, CBL=cobble DEPTH=depth, GR=gravel, LIGHT=light level, SASI=sand/silt, UCB=undercut banks,

Table 2.-Cont'd

VEG=aquatic macrophytes, 1°=primary substrate, 2°=secondary substrate, A=absent, P=present, LOW=0500 to 0900 hours and 1700 to 2100 hours, HIGH=0900 to 1700 hours.

[b] 1=0 to 0.33 m, 2=0.33 to 0.67 m, 3=0.67 to 1.00 m, 4=1.00 to 1.33 m, 5=1.33 to 1.67 m, 6=1.67 to 2.00 m, 7=greater than 2.00 m.

lack of fit can be observed in the plot of observed vs. predicted proportions (probabilities) of events (young) based on the 58 different microhabitats sampled (Fig 3). If observed proportions matched predicted proportions, the model could predict an event or non-event based on the unique microhabitats. However, observed proportions of 1 (100% events based on the microhabitat) were generally higher than the predicted proportions of events based on the model. Likewise, observed proportions of 0 (100% non-events based on the microhabitat) were generally lower than the predicted proportions of non-events based on the model.

Many microhabitats had observed proportions between 0.3 and 0.7, indicating that young and adults overlap in use of pool microhabitats (Table 2 and Fig. 2). Additional evidence for overlap is implied by the fact that all levels of every habitat variable were used by young and adults. For example, although young typically avoided water greater than 2 m deep and were found in the shallowest water more often than adults (Chi square=28.3, 6 d.f., p<.001), all depths were used by both age groups (Fig. 4). Likewise, cobble substrates were used more often by young (Chi square=8.74, 2 d.f., p=.013; Fig. 5) as were aquatic macrophytes (Chi square=2.77, 1 d.f., p=.096; Fig. 6) and undercut banks were used more often by adults (Chi square=5.67, 1 d.f., p=.017; Fig. 7). A higher proportion of young were sampled during high light level time periods

Figure 3.-Plot of the predicted proportions of young (from the logistic regression model) versus the actual observed proportions of young in pools of the Buffalo River, Arkansas.

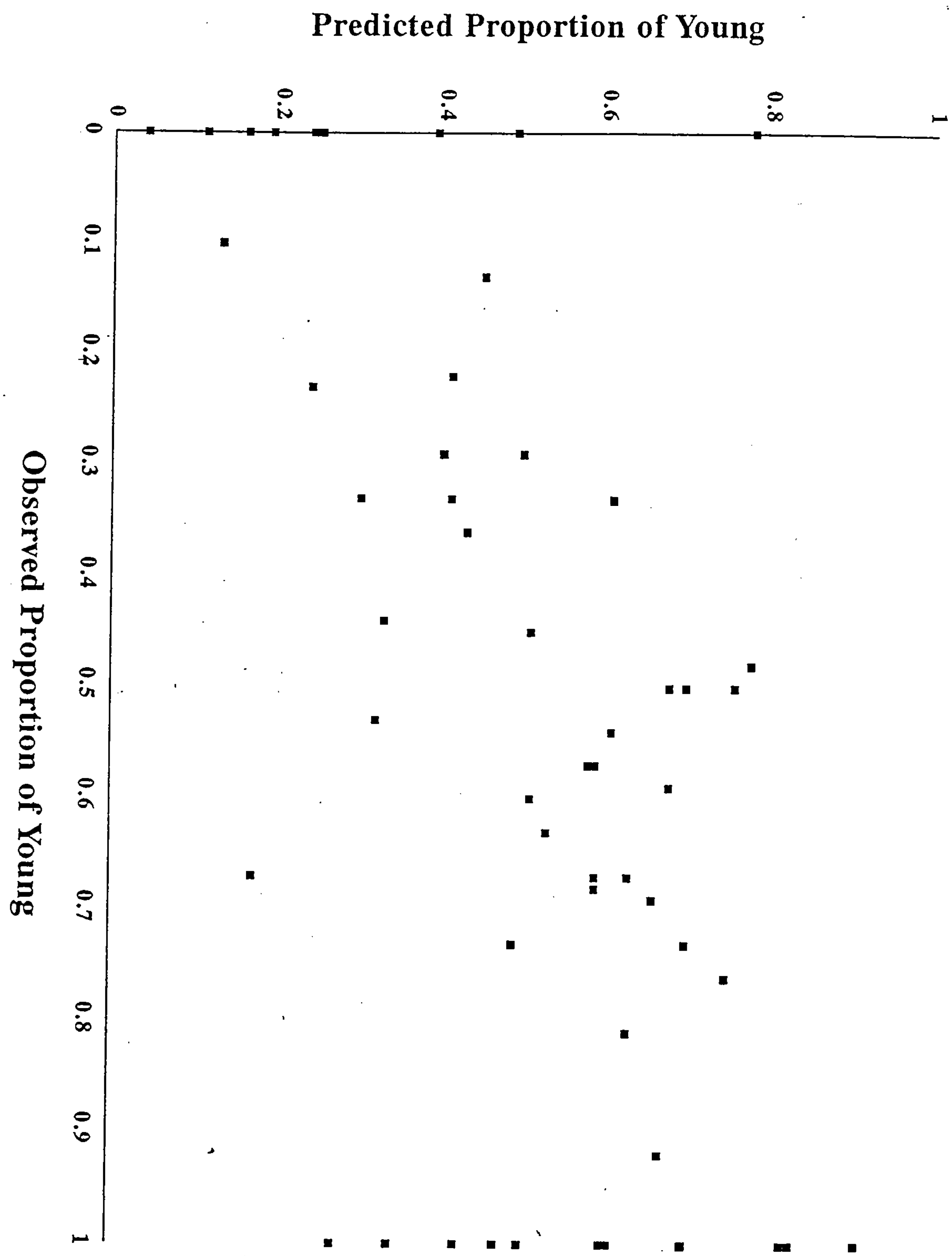
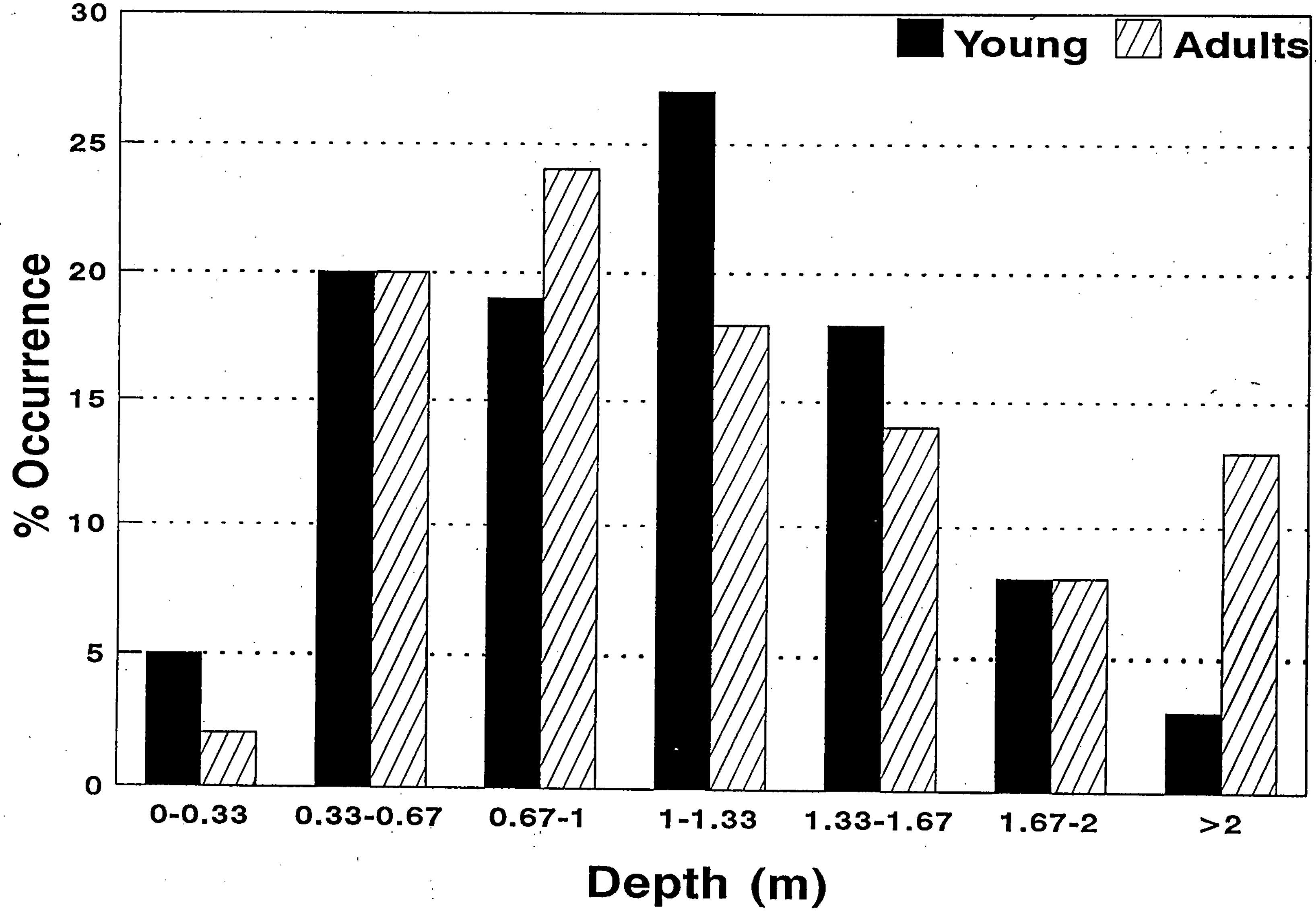

Predicted Proportion of Young
0
0.2
0.4
0.6
0.8
1
Observed Proportion of Young
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Figure 4.-Percent occurrence of smallmouth bass by depth intervals in pools of the Buffalo River, Arkansas.



% Occurrence
30
25
20
15
10
5
0
Young
Adults
0-0.33
0.33-0.67
0.67-1
1-1.33
1.33-1.67
1.67-2
>2
Depth (m)

Figure 5.-Percent of young and adult smallmouth bass using cobble substrates in pools.

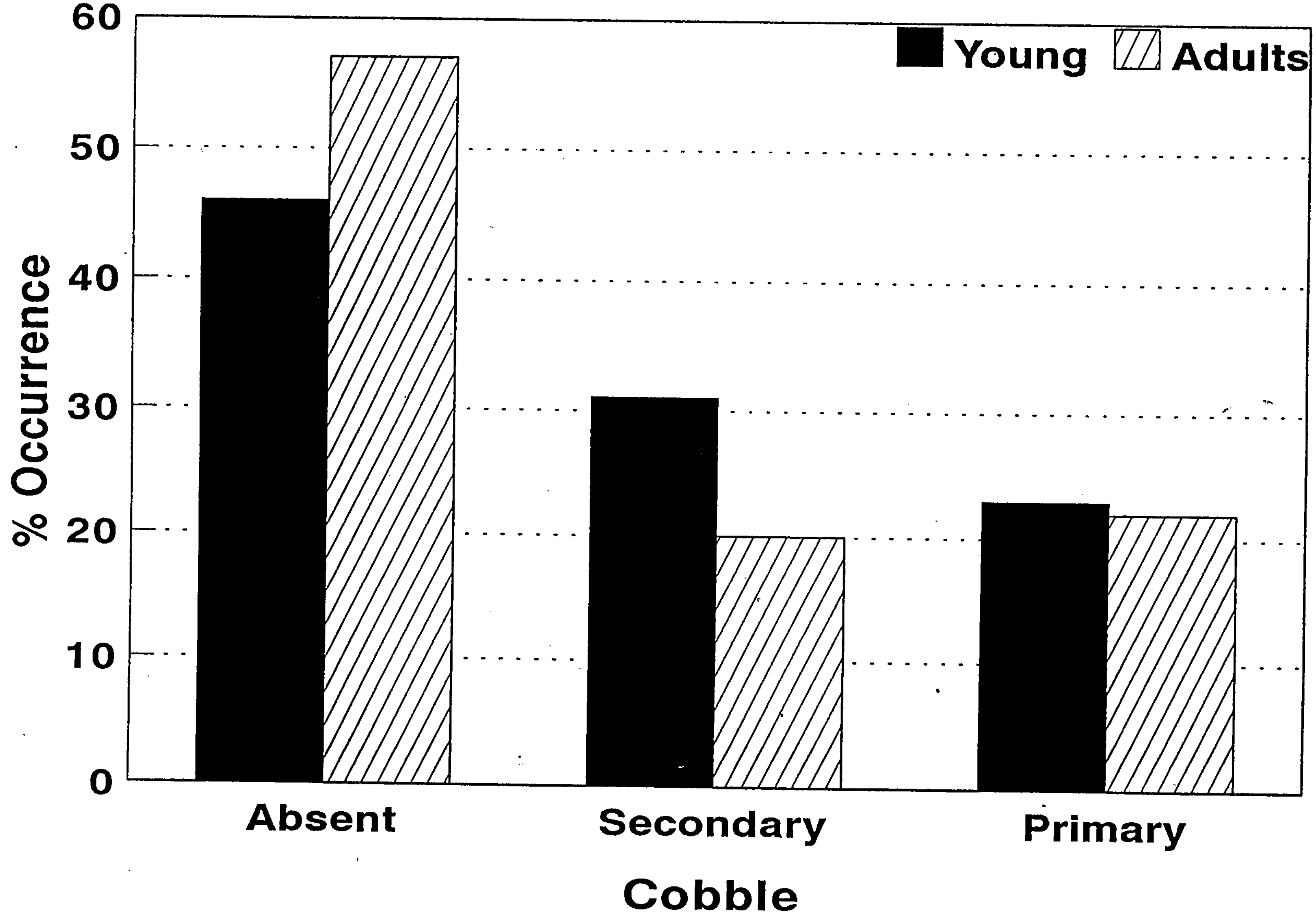

% Occurrence
60
50
40
30
20
10
0
Young
Adults
Absent
Secondary
Primary
Cobble

Figure 6.-Percent of young and adult smallmouth bass using aquatic macrophytes in pools.

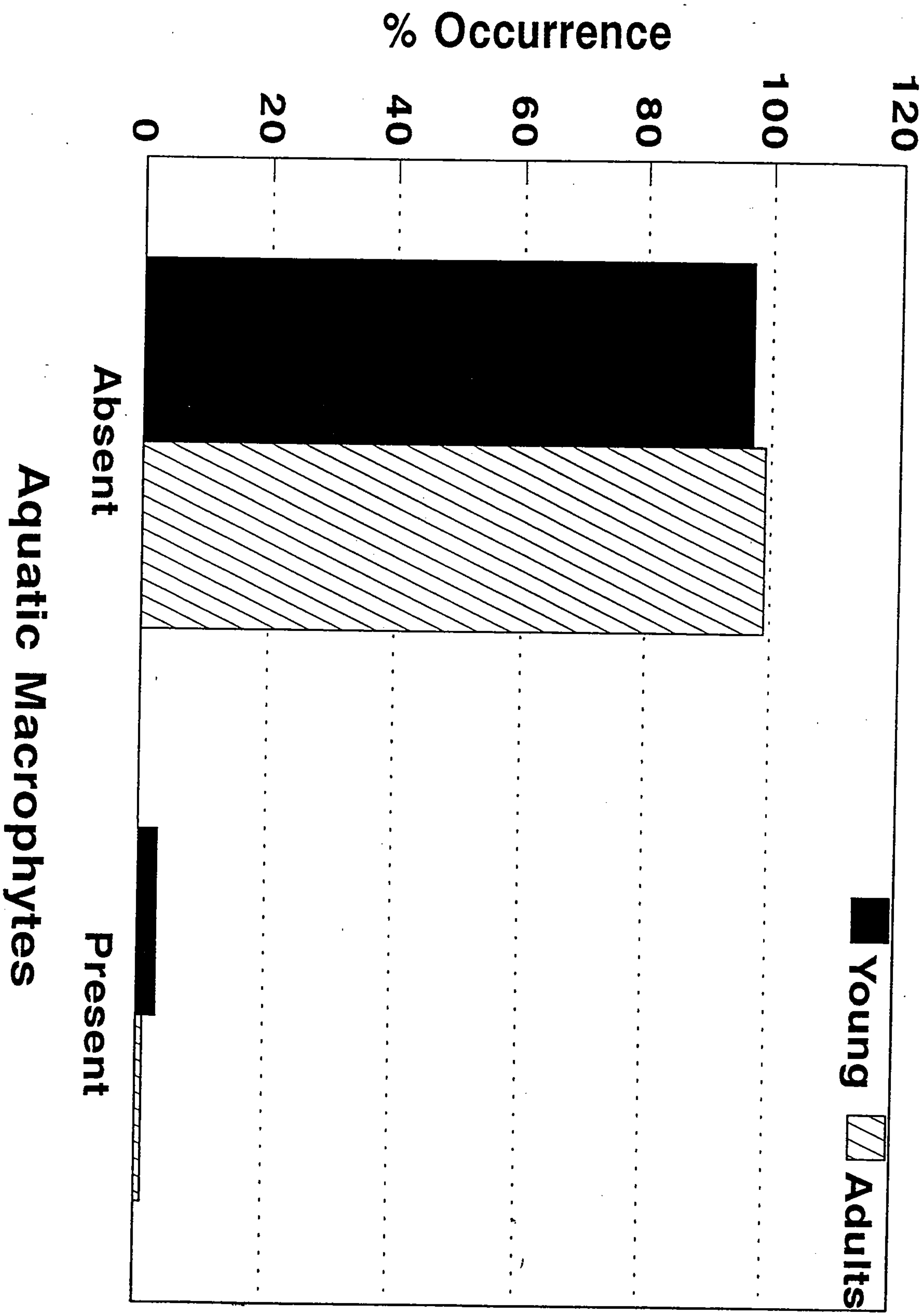
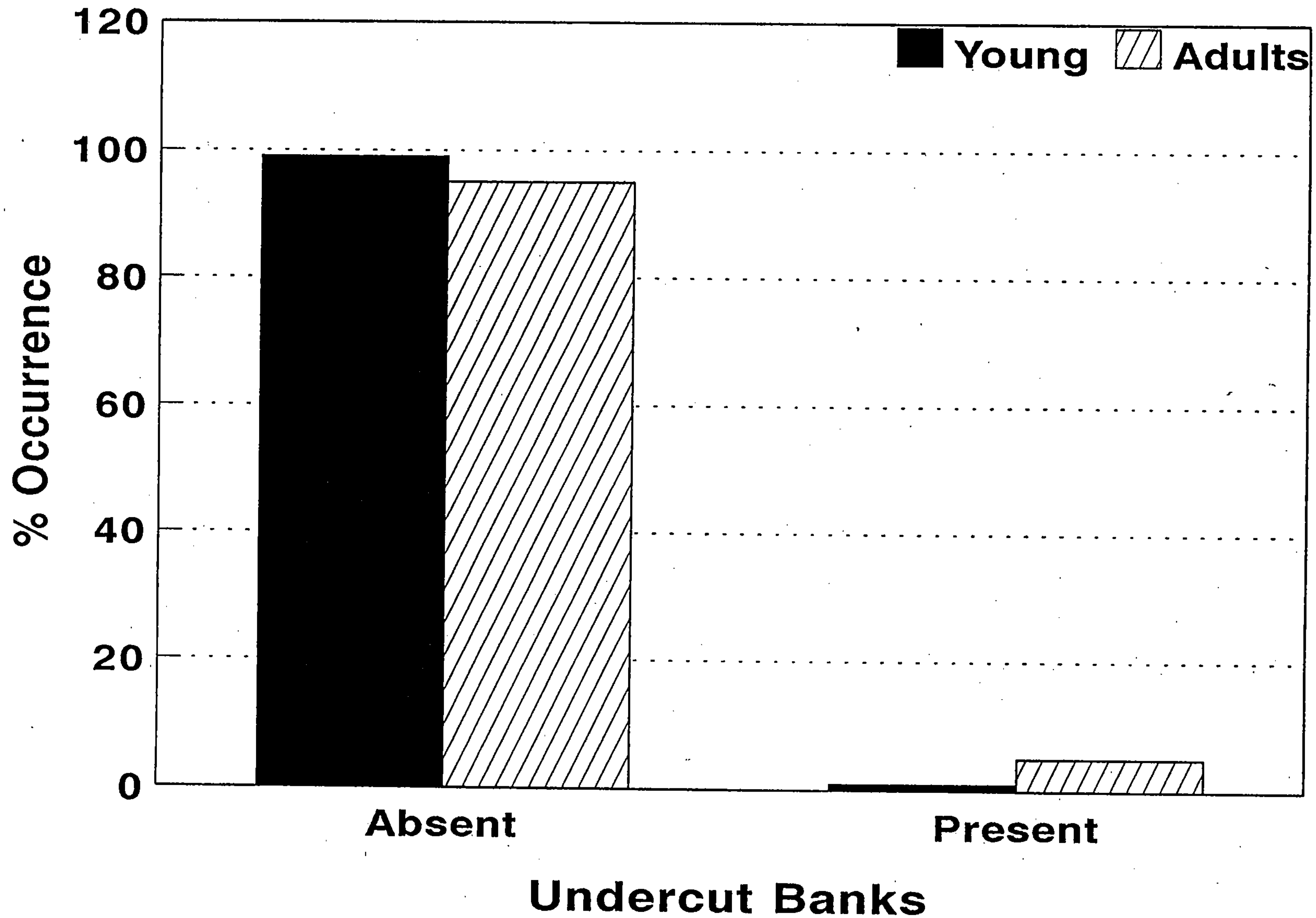

% Occurrence
0
20
40
60
80
100
120
Absent
Present
Aquatic Macrophytes
Young
Adults

Figure 7.-Percent of young and adults using undercut banks in pools.


% Occurrence
120
100
80
60
40
20
0
Young
Adults
Absent
Present
Undercut Banks

(Chi square=16.4, 1 d.f., $p<.001$; Fig.8), but both age groups were observed during both high and low light levels. Microhabitats showing overlap in use, but with fewer than 10 observations are not included in Table 2.

Microhabitat Use-Runs

Six variables were significant in discriminating between the presence of young and adult smallmouth bass in runs (Table 1). Smallmouth bass were found in 36 different microhabitats in runs. The model producing the highest probability of occurrence of young in runs was:

X = .5136(when LIGHT=High) + 2.4725(when BR=2° substrate) + .6488(when SASI=Absent) + 1.1509(when GR=Absent) + .8927(when VEG=Present) + .4851(when BDCOV=Absent)

giving P=.9974

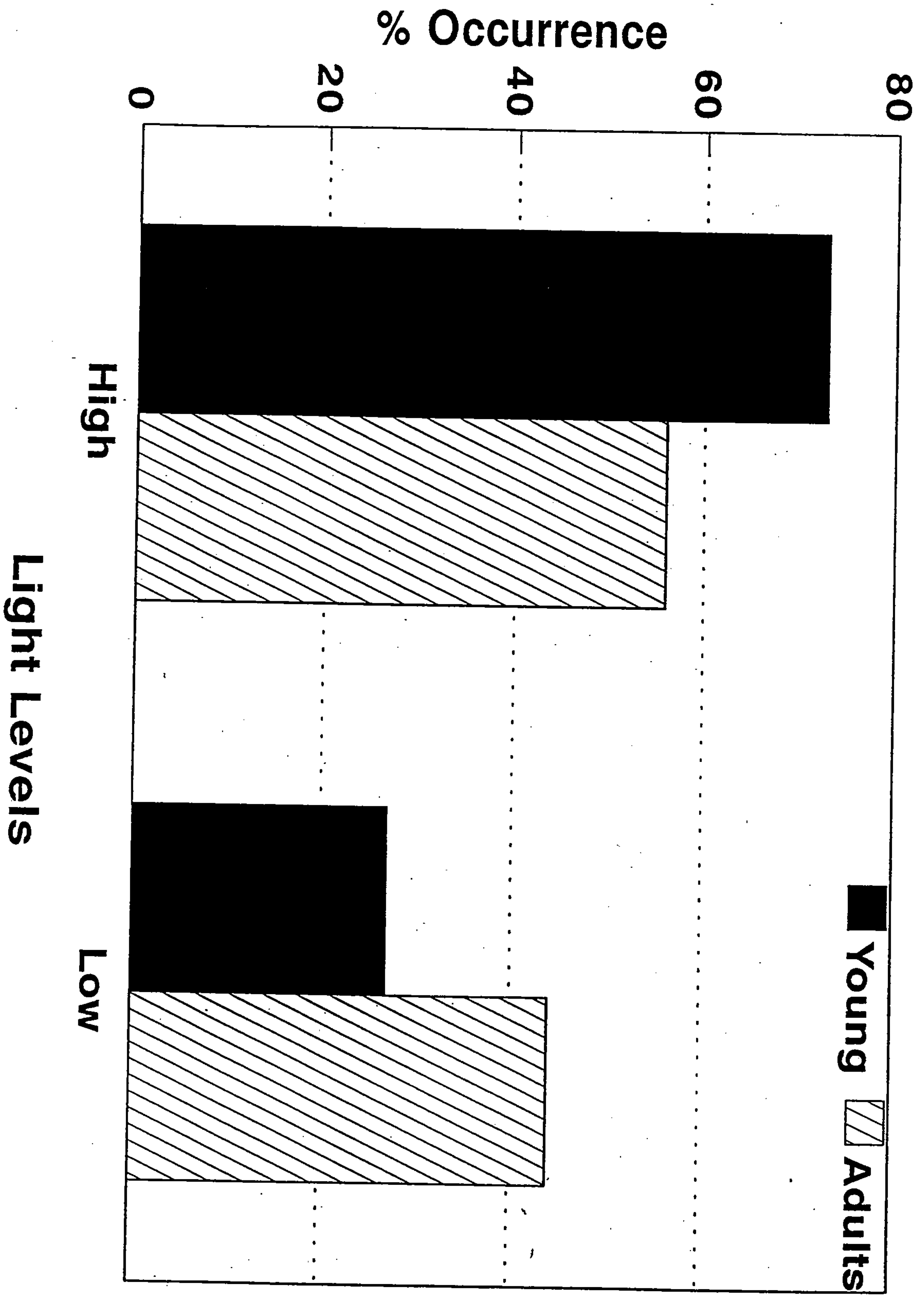
The model producing the highest probability of occurrence of adults in runs was:

X = -.5136(when LIGHT=Low) - 2.2192(when BR=1° substrate) - .8345(when SASI=1° substrate) - .9661(when GR=1° substrate) - .8927(when VEG=Absent) - .4851(when BDCOV=Present)

giving P=.0027

For run microhabitats with 10 or more observations, five had low proportions of events, whereas none had high

Figure 8.-Percent of young and adults observed during high and low light level periods in pools.

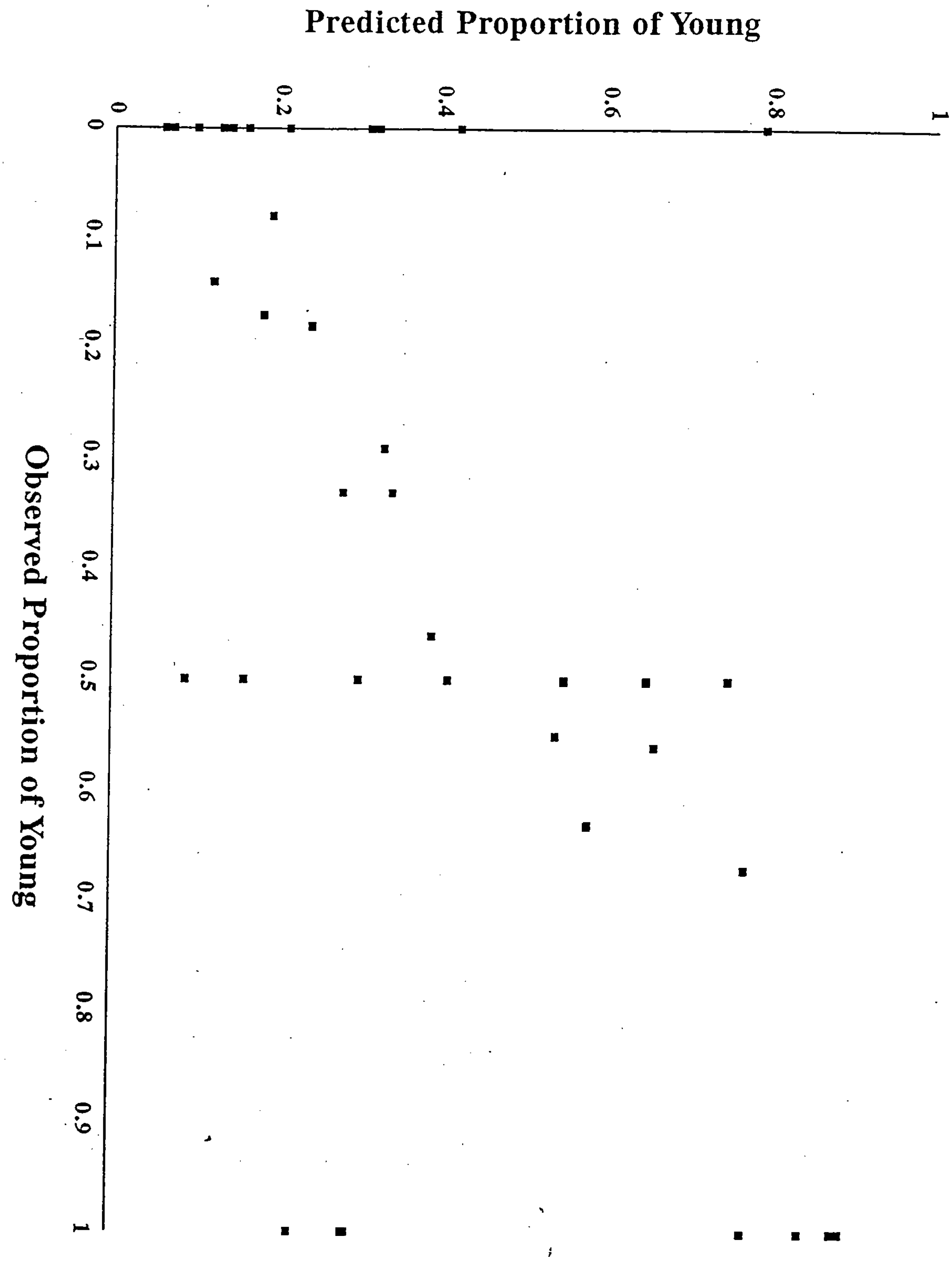

% Occurrence
0
20
40
60
80
Young
Adults
High
Low
Light Levels

proportions of events (Table 2). Thus, in runs, some microhabitats are inhabited mainly by adults, whereas none are occupied mainly by young. Adult microhabitats generally included finer grained substrates such as sand/silt and gravel, during high light levels. One included the presence of boulder cover. Adults and young overlapped in runs, with many microhabitats showing observed proportions of events between 0.3 and 0.7. The resulting model did not fit the data well (Chi square=42.08, 27 d.f., p=.0323) and therefore had poor overall power in predicting the probabilities of an event for the various microhabitats (Fig. 9).

Vertical Segregation

Young and adult smallmouth bass were segregated vertically within the water column in both runs and pools, according to focal point depth (FPD) measurements. In pools, young were found at a mean FPD of 7 cm, while adults occurred at a mean FPD of 28 cm. This difference was significant at the .0001 level (Kruskal-Wallis test, Chi square=89.609, 1 d.f.). Focal point depths of young ranged from 0 to 80 cm and from 0 to 1.1 m for adults. In runs, young occurred at a mean FPD of 5 cm, while adults occurred at a mean FPD of 10 cm. This difference was significant at the .0035 level (Kruskal-Wallis test, Chi square=28.54, 1 d.f.). The range for young was 0 to 60 cm and 0 to 40 cm

Figure 9.-Plot of the predicted proportions of young (from the logistic regression model) versus the actual observed proportions of young in runs of the Buffalo River, Arkansas.


Predicted Proportion of Young
0
0.2
0.4
0.6
0.8
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Observed Proportion of Young

for adults.

Discussion

Macrohabitat Distribution

The disproportionately high number of young sampled in pools may be a result of a sampling bias, since some adults observed in pools had reacted to my presence before I could get accurate microhabitat information. Nevertheless, pools and runs are important macrohabitats for both young and adult smallmouth bass in the Buffalo River. The relatively deep water and large boulders of pools are probably important sources of cover for adults. It is possible that the shallower water of runs and nearby riffles provides higher primary productivity, and thus larger numbers of primary and secondary consumers, important forage for the adults. Underwater observations showed these habitats to be occupied by Campostoma spp. grazing on algae, and shiners (Cyprinella, Luxilus, and Notropis), feeding on drift, especially in riffles and in runs immediately below riffles. Minnows are important forage for smallmouth bass adults in the Buffalo River (Whisenant and Maughan 1989). Both adults and young were occasionally observed in riffles as well.

The high proportion of adults relative to young sampled in runs of the Buffalo River contrasts with the very low densities of adults in the raceways (runs) and riffles of Jordan Creek, Illinois (Schlosser 1987). Jordan Creek is generally a lower gradient stream than the Buffalo River, with a higher percentage of silt, sand and gravel, and some sections of channelized stream (Schlosser 1982). This difference in morphology between the two streams may affect the relative distribution of adults to young at the macrohabitat level. However, adults were described as members of a pool guild in James River, Virginia tributary streams, which had more similar geomorphologies to the Buffalo River (Leonard and Orth 1988). The distribution of adults in the Buffalo River resembles that of the West River, Vermont, and the New River, West Virginia, where they are habitat generalists (Bain et al. 1988; Lobb and Orth 1991).

Young smallmouth bass may find more cover in pools relative to runs but, like adults, may forage more efficiently in runs and riffles, explaining their presence in these habitats. In Jordan Creek, Illinois and the New River, West Virginia, young were sampled in pools, runs and riffles, but were most abundant in pools, as in the Buffalo River (Schlosser 1987; Lobb and Orth 1991). In the James River, Virginia, young and juvenile smallmouth bass are members of a run guild of fishes, and in the West River, Vermont, young are restricted to habitat characterized by very shallow and slow currents (Bain et al. 1988; Leonard and Orth 1988). In contrast, my results indicate that young are also generalists at the macrohabitat level in the Buffalo River.

Microhabitat Use-Pools

Based on the logistic regression analysis, there was evidence of intraspecific microhabitat segregation of smallmouth bass in the Buffalo River. In pools, microhabitats inhabited mainly by young consisted of mid-depths over cobble substrates, during high light level periods. It is not clear why these particular microhabitats should be used primarily by young, but the most important factor may be the presence of cobble. Cobble was absent from most pool microhabitats occupied mainly by adults but was present in all but one microhabitat occupied mainly by young. Young are known to choose cobble substrates in some streams (Livingstone and Rabeni 1987; Leonard and Orth 1988), whereas gravel, cobble and boulders are all preferred substrates of adults (Reynolds 1965; Hubert 1981; Paragamian 1981; Rankin 1986). Studies have also shown a positive relationship between the percent of cobble in a stream and adult smallmouth bass numbers (Paragamian 1981; McClendon and Rabeni 1987).

In the Buffalo River, it is probable that cobble plays a more important role to young-of-the-year smallmouth bass, than to adults. At this stage of life, cobble is large enough to provide cover for the small young. Underwater observations showed that the young often used cobble as cover in areas lacking other cover such as boulder and aquatic vegetation. Often, young were observed immediately adjacent to or beneath a single piece of cobble in an area surrounded by gravel or no other cover. This situation is analogous to a larger bass using a boulder in an area otherwise surrounded by smaller substrates such as gravel and cobble which may not provide adequate cover. These observations were made both on transects and during focal animal sampling of young. Young may also avoid other cover types, such as boulders and snags, if they are occupied by larger predators. The cobble substrate also provides forage (other fish, invertebrates) for the young (personal observation), though further research would be needed to compare the quality and quantity of food consumed by young in microhabitats with cobble substrates vs. other microhabitats.

The use of mid-depth ranges by young may be in response to predators which frequent the shallower areas of the stream. Great blue herons, green-backed herons, belted kingfishers and mink were all observed along the banks of the Buffalo River. Power (1984) suggested that loricarriid catfish in a Panama stream may avoid shallow water due to the birds and mammals that fish there, even though algae, a major food source, was plentiful in the shallow water. Smallmouth bass young were also found in the shallowest areas where the model predicted they would be most segregated from adults, but these observations were few. Thus, Buffalo River smallmouth bass young utilized shallow and mid depth areas of the stream as they do in some upper midwest and eastern U.S. streams (Rankin 1986; Leonard and Orth 1988; Lobb and Orth 1991), but are not restricted to shallow areas, as in the West River, Vermont (Bain et al. 1988). Fewer young were found in the deepest water, agreeing with Lobb and Orth (1991) who found densities of young to be negatively correlated with depth in the New River, West Virginia.

Light levels apparently have some affect on microhabitat use which is not fully understood. More young were sampled during high light levels than low. This may be due to the young seeking cover during low light levels, and thus becoming less susceptible to my sampling. Some predator fish are known to be more active near sunrise and sunset (Emery 1973; Helfman 1986; Todd and Rabeni 1989). The young may respond to these patterns by seeking cover during these times. Young were often segregated from adults in microhabitats with cobble substrates, a potential source of cover, during both high and low light periods. However, when cobble was lacking, young were present in high proportions during high light levels, but in low proportions during low light level periods when predation risk may have been greater.

Adults may not have an affinity for cobble as young appear to have, finding it less effective as a source of cover and food. Two microhabitats occupied primarily by adults were found in the deepest water. This may be a result of young avoiding the deepest parts of the river due to limited available food and/or cover. However, some young were sampled at these depths in other microhabitats and thus are not completely absent from the deepest parts of the stream. Other studies have shown adults to generally use depths less than 2 m (Probst et. al. 1984; Rankin 1986; Leonard and Orth 1988; Todd and Rabeni 1989) except during cold (<16 ^{o}C) water periods (Munther 1970; Langhurst and Schoenike 1990).

Microhabitat Use-Runs

In runs, there was more evidence that adults were segregated from young. It is unclear why young typically were not found in these microhabitats. The substrate was either gravel or sand/silt, boulders were generally absent as a cover type and aquatic vegetation was always absent. Perhaps the relatively fine grained substrates with little or no cover made these microhabitats unattractive to young. Adults are generally associated with some type of cover also, such as woody debris (snags) and boulders (Leonard and Orth 1988, Lobb and Orth 1991, Probst et. al. 1984, Todd and Rabeni 1989). Boulders were present in only one of the run microhabitats used mainly by adults in the Buffalo River and SNAG was not a significant variable in the model, thus snags may or may not have occurred in the four microhabitats occupied primarily by adults. The absence of aquatic vegetation in these microhabitats agrees with the findings of Lobb and Orth (1991) who concluded that vegetation was not an important cover type for adults in the New River, West Virginia. The relatively sparse occurrence of aquatic vegetation in the Buffalo River makes it difficult to ascertain its importance as a cover type.

Vertical Segregation

Smallmouth bass also showed intraspecific vertical segregation in the water column of the Buffalo River, with young generally occurring close to the substrate, and adults occurring farther above the substrate. Dolloff and Reeves (1990) found focal point depths of age 0 coho salmon (*Oncorhyncus kisutch*) and Dolly Varden (*Salvelinus malma*) closer to bottom than age 1 fish in Alaska streams. This pattern has not been documented for smallmouth bass in lotic systems. Young smallmouth bass are not confined to the area at and immediately above the substrate however, and overlap in this vertical distribution occurs as well. Young may prefer to stay near the substrate as it may provide cover from predators. The adult fish have few if any predators within the system and can therefore roam more freely away from cover. Underwater observations of young also showed extensive foraging occurring at the surface of the substratum.

Management Implications

Logistic regression analysis is fairly new to fisheries work. Thielke (1985) used the technique to develop suitability-of-use functions for rainbow trout (Onchorynchus mykiss) by using data from microhabitats where fish were observed present and other microhabitats where they were assumed absent. His analysis resulted in independent variables useful in discriminating between the presence and absence of trout in western Washington streams. Lyons (1991) used a logistic regression model to correctly predict the presence or absence of smallmouth bass (all ages) in 67% of stations sampled in Wisconsin streams, based on measurements of habitat variables. His model showed that bass were most likely to occur in areas with stream widths greater than 8 m, gradients from 1 to 5 m/km, substrates greater than 45% rock (includes gravel, cobble, boulder and bedrock) and summer water temperatures greater than 22 °C.

In the present study, I took what I consider the next step after Lyons' (1991) work, with the investigation of possible microhabitat segregation within a stream already known to have excellent smallmouth bass habitat. Logistic regression analysis proved useful in identifying microhabitat segregation between young and adult smallmouth bass in the Buffalo River, and in identifying habitat variables important to this segregation.

Results also show extensive microhabitat overlap between young and adults. It is possible that this is an artifact of the sampling design. Since I made fewer than ten observations in many microhabitats, an increased sample size may have identified more microhabitats where segregation occurs. Measuring additional habitat variables also might be helpful in identifying microhabitats where segregation may occur. For example, flow rates were not measured in this study, but they have been shown to be an important variable in smallmouth bass habitat use (Simonson and Swenson 1990). However, my observations did not show any obvious segregation of age groups based on flow rates in this study.

Results of this study show both differences and similarities in habitat use of Buffalo River smallmouth bass compared to other streams and support the need to identify important habitat needs at the local level as suggested by Reiser et al. (1989). For example, a survey of smallmouth bass young densities in the Buffalo River with the assumption that young inhabit only the shallow edges of pools and shallower runs (as some studies have shown), would probably give erroneous results. Likewise, some studies have shown smallmouth bass young to utilize microhabitats with aquatic vegetation (George and Hadley 1979; Dowling 1987; Livingstone and Rabeni 1987). Aquatic vegetation appears to be a less important microhabitat variable to young in the Buffalo River. Cobble was also found to be an important microhabitat variable for young in the Buffalo River, in part supporting Paragamian's (1981) argument for stocking smallmouth young in stream segments that contain gravel and cobble in combination with pools.

Future studies should address possible intraspecific microhabitat segregation in other streams and investigate the mechanisms leading to intraspecific segregation and its' importance both from management and ecological perspectives.

References

Agresti, A. 1990. Categorical Data Analysis. John Wiley and Sons, New York. 558 pp.

Babcock, R. E., E. E. Dale, H. C. MacDonald, R. L. Meyer, D. G. Parker, E. B. Smith and K. F. Steele. 1976. Buffalo National River Ecosystems Part II. Water Resources Research Center Publication No. 38, University of Arkansas. 279 pp.

Bain, M. B., J. T. Finn and H. E. Booke. 1988. Streamflow regulation and fish community structure. Ecology 69:382-392.

Baltz, D. M., B. Vondracek, L. R. Brown, and P. B. Moyle. 1991. Seasonal changes in microhabitat selection by rainbow trout in a small stream. Transactions of the American Fisheries Society 120:166-176.

Beschta, R. L. and W. S. Platts. 1986. Morphological features of small streams: significance and function. Water Resources Bulletin 22:369-379.

Bovee, K. D., and R. Milhouse. 1978. Hydraulic simulation in instream flow studies: theory and techniques. Instream flow information paper 5. United States Fish and Wildlife Service Biological Services Program FWS/OBS-78/33.

Brock, V. E. 1954. A preliminary report on a method of estimating reef fish populations. Journal of Wildlife Management 18:297-308.

Coble, D. W. 1975. Smallmouth bass. Pages 21-33 in R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Inst., Washington, D. C.

Croneis, C. 1930. Geology of the Arkansas Paleozoic area, with especial reference to oil and gas possibilities. Arkansas Geological Survey Bulletin No. 3.

Decker, L. M. 1989. Coexistence of two species of sucker, Catostomus, in sagehen Creek, California, and notes on their status in the western Lahontan Basin. Great Basin Naturalist 49:540-551.

Dibble, E. D. 1991. A comparison of diving and rotenone methods for determining relative abundance of fish. Transactions of the American Fisheries Society 120:663-666.

Dolloff, C. A. and G. H. Reeves. 1990. Microhabitat partitioning among stream-dwelling juvenile coho salmon, Oncorhynchus kisutch, and Dolly Varden, Salvelinus malma. Canadian Journal of Fisheries and Aquatic Sciences 47:2297-2306.

Dowling, D. C. 1987. Population dynamics of, and habitat utilization by, young-of-the-year rock bass (Ambloplites rupestris) and smallmouth bass (Micropterus dolomieui) in a warmwater stream. Masters thesis. Michigan State University, East Lansing.

Edwards, E. A., G. Gebbart, and O. E. Maughan. 1983. Habitat suitability information: Smallmouth bass. United States Department of the Interior, Fish and Wildlife Service FWS/OBS-82/10.36.

Emery, A. R. 1973. Preliminary comparisons of day and night habits of freshwater fish in Ontario Lakes. Journal of the Fisheries Research Board of Canada 30:761-774.

Feminella, J. W. and W. J. Matthews. 1984. Intraspecific differences in thermal tolerance of Etheostoma spectabile in constant versus fluctuating environments. Journal of Fish Biology 25:455-461.

George, E. L. and W. F. Hadley. 1979. Food and habitat partitioning between rock bass (Ambloplites rupestris) and smallmouth bass (Micropterus dolomieui) young of year. Transactions of the American Fisheries Society 108(3):253-261.

Gorman, O. T. 1987. Habitat segregation in an assemblage of minnows in an Ozark stream. Pages 33-41 in W. J. Matthews and D. C. Heins, editors. Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press, Norman.

Grossman, G. D., A. de Sostoa, M. C. Freeman, and J. Lobon-Cervia. 1987. Microhabitat use in a Mediterranean riverine fish assemblage, fishes of the lower Matarrana. Oecologia 73:490-500.

Helfman, G. S. 1986. fish behaviour by day, night and twilight. Pages 366-387 in T. J. Pitcher, editor. The Behavior of Teleost Fishes. The Johns Hopkins University Press, Baltimore, Maryland. 553 pp.

Helm W. T., P. Brouha, M. Aceituno, C. Armour, P. Bisson, J. Hall, G. Holton and M. Shaw. 1985. Glossary of stream habitat terms. American Fisheries Society, Bethesda, Maryland. 34 pp.

Hubert, W. 1981. Spring movements of smallmouth bass in the Wilson Dam tailwater, Alabama. Journal of the Tennessee Academy of Science 56:105-106.

Hurlbert, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54:187-211.

Kilambi, R. V., W. R. Robison, and J. C. Adams. 1977. Growth,mortality, food habitats, and fecundity of the Buffalo River smallmouth bass. Proceedings of the Arkansas Academy of Science 31:62-65.

Langhurst, R. W. and D. L. Schoenike. 1990. Seasonal migration of smallmouth bass in the Embarrass and Wolf Rivers, Wisconsin. North American Journal of Fisheries Management 10:224-227.

Leonard, P. M. and D. J. Orth. 1988. Use of habitat guilds of fishes to determine instream flow requirements. North American Journal of Fisheries Management 8:399-409.

Lobb, D. M. III and D. J. Orth. 1991. Habitat use by an assemblage of fish in a large warmwater stream. Transactions of the American Fisheries Society 120:65-78.

Livingstone, A. C. and C. F. Rabeni. 1987. Food and habitat use of young-of-year centrarchids in the Jacks Fork River, Missouri. Completion report to the National Park Service. 140 pp.

Lyons, J. 1991. Predicting smallmouth bass presence/absence and abundance in Wisconsin streams using physical habitat characteristics. Pages 96-103 <u>in</u> D. C. Jackson, ed. The First International Smallmouth Bass Symposium. American Fisheries Society, Southern Division.

Matheson, R. E. Jr. and G. R. Brooks, Jr. 1983. Habitat segregation between Cottus bairdi and Cottus girardi: an example of complex inter- and intraspecific resource partitioning. American Midland Naturalist 110:165-176.

McClendon, D. D. and C. F. Rabeni. 1987. Physical and biological variables useful for predicting population characteristics of smallmouth bass and rock bass in an Ozark stream. North American Journal of Fisheries Management 7:46-56.

Miller, P. J. 1979. A concept of fish phenology. Symposia of the Zoological Society of London 44:1-28.

Moyle, P. B. and D. M. Baltz. 1985. Microhabitat use by an assemblage of California stream fishes: developing criteria for instream flow determinations. Transactions of the American Fisheries Society 114:695-704.

Moyle, P. B., J. J. Smith, R. A. Daniels, and D. M. Baltz. 1982. Distribution and ecology of stream fishes of the Sacramento-San Joaquin drainage system, California. IV. A review. University of California Publications in Zoology 115:225-256.

Moyle, P. B., and B. Vondracek. 1985. Persistence and structure of the fish assemblage in a small California stream. Ecology 66:1-13.

Munther, G. L. 1970. Movement and distribution of smallmouth bass in the Middle Snake River. Transactions of the American Fisheries Society 99:44-53.

Orth, D. J. 1987. Ecological considerations in the development and application of insteam flow-habitat models. Regulated Rivers:Research and Management 1:171-181.

Paragamian, V. L. 1981. Some habitat characteristics that affect abundance and winter survival of smallmouth bass in the Maquoketa River, Iowa. Pages 45-53 in L. A. Krumholz, ed. The warmwater streams symposium. Southern Division, American Fisheries Society, Lawrence, KS.

Pianka, E. R. 1973. The structure of lizard communities. Annual Review of Ecology and Systematics 4:53-74.

Petersen, J. C. 1992. Trends in stream water-quality data in Arkansas during several time periods between 1975 and 1989. U.S. Geological Survey Water-Resources Investigations Report 92-4044.

Power, M. E. 1984. Depth distributions of armored catfish: predator-induced resource avoidance? Ecology 65:523-528.

Probst, W. E., C. F. Rabeni, W. G. Covington, and R. E. Marteney. 1984. Resource use by stream dwelling rock bass and smallmouth bass. Transactions of the American Fisheries Society 113:283-294.

Rankin, E. T. 1986. Habitat selection by smallmouth bass in response to physical characteristics in a natural stream. Transactions of the American Fisheries Society 115:322- 334.

Reiser, D. W., T. A. Wesche, and C. Estes. 1989. Status of instream flow legislation and practices in North America. Fisheries 14(2):22-29.

Reynolds, J. B. 1965. Life history of smallmouth bass, Micropterus dolomieui Lacepede, in the Des Moines River, Boone County, Iowa. Iowa State Journal of Science 39:417-436.

Reynolds, W. W. and M. E. Casterlin. 1976. Activity rhythms and light intensity preferences of Micropterus salmoides and M. dolomieui. Transactions of the American Fisheries Society (1976):400-403.

SAS Institute Inc. 1989. SAS/STAT User's Guide, Version 6, Fourth Edition, Volume 1. SAS Institute, Cary, North Carolina. 943pp.

Schlosser, I. J. 1982. Fish community structure and function along two habitat gradients in a headwater stream. Ecological Monographs 52:395-414.

Schlosser, I. J. 1987. The role of predation in age- and size-related habitat use by stream fishes. Ecology 68:651-659.

Simonson, T. D. and W. A Swenson. 1990. Critical stream velocities for young-of-year smallmouth bass in relation to habitat use. Transactions of the American Fisheries Society 119:902-909.

Thielke, J. 1985. A logistic regression approach for developing suitability-of-use functions for fish habitat. Pages 32-38 in F. W. Olson, R. G. White and R. H. Hamre editors. Proceedings of the Symposium on Small Hydropower and Fisheries. American Fisheries Society, Bethesda, Maryland. 497 pp.

Todd, B. L. and C. F. Rabeni. 1989. Movement and habitat use by stream-dwelling smallmouth bass. Transactions of the American Fisheries Society 118(3):229-242.

Whisenant, K. A. and O. E. Maughan. 1989. Smallmouth bass and Ozark bass in Buffalo National River. Cooperative National Park Resources Studies Unit Technical Report No. 28.

USGS (United States Geological Survey). 1988. Water resources data for Arkansas. U.S. Geological Survey water-data report AR-88-1, Washington D.C.

APPENDIX

SURVEY OF THE FISHES OF BUFFALO NATIONAL RIVER, ARKANSAS

SURVEY OF THE FISHES OF BUFFALO NATIONAL RIVER, ARKANSAS

A survey of fish species diversity and distribution was conducted on the Buffalo National River by Arkansas Cooperative Fish and Wildlife Research Unit personnel from June 1990 through October 1992. Various sampling techniques were used including seining, hoop netting, backpack electrofishing, boomshocking, and underwater observations, though usually only one or two of these methods were used for any given site. A total of 23 different sites were sampled beginning in the headwaters near Fallsville and continuing to the confluence with the White River (Fig. 1). In this total were three Buffalo River tributaries including Clark Creek and Whiteley Creek in Boxely Valley, and Mitch Hill Spring near Mt. Hersey. For this report, sites were grouped into upper middle and lower reaches of the river.

A total of 53 species and 1 _Lepomis_ hybrid were sampled for the 3 reaches combined (Table 1). Species reported from other Buffalo River surveys (Black 1940; Guidroz 1975; Cashner and Brown 1977; Kilambi and Becker 1977), but not taken in the present survey include _Lampetra appendix_, _Dorosoma cepedianum_, _Cyprinella whipplei_, _Notemigonus crysoleucas_, _Carpiodes velifer_, _Ameiurus melas_, _Micropterus punctulatus_, _Etheostoma stigmaeum_, and _Percina maculata_. Our sampling methods and effort may have missed some of these species, though some appear to be relatively rare or extirpated from the Buffalo River drainage. For example, Cashner and Brown (1977) did not take Cyprinella whipplei, Notemigonus crysoleucas, or Percina maculata in their survey; and they took Ameiurus melas at only one site, as did Guidroz (1975). Etheostoma stigmaeum was taken at only one site on the lower river by Guidroz (1975) and sampled only on the lower river by Cashner and Brown (1977).

One new species taken in this survey, Carpiodes carpio, is listed by Robison and Buchanan (1987) for the White River system, but no reports for the Buffalo River are mentioned. This species was collected on two different occasions at Buffalo Point. Two other new species, Lepomis microlophus and Pomoxis nigromaculatus, were also taken in this survey. These new additions to the Buffalo River fish fauna probably resulted from stockings by the Arkansas Game and Fish Commission. One species, Cottus hypselurus, was recently described by Robins and Robison (1985) and replaces what was formerly referred to as Cottus bairdi throughout much of the Ozarks, including the Buffalo River. Another species, listed as Ambloplites rupestris by Guidroz (1975), was listed simply as Ambloplites sp. by Cashner and Brown (1977) as they believed this to be a new form of rock bass. Cashner and Suttkus (1977) later described this form as a new species, Ambloplites constellatus.

The genera to which the following species are assigned changed (American Fisheries Society 1991) since the last survey was conducted on the Buffalo River (Cashner and Brown 1977):

New Name	Former Name
Lampetra appendix	*Lampetra lamottei*
Cyprinella galactura	*Notropis galacturus*
Cyprinella whipplei	*Notropis whipplei*
Erimystax dissimilis	*Hybopsis dissimilis*
Luxilus chrysocephalus	*Notropis chrysocephalus*
Luxilus pilsbryi	*Notropis pilsbryi*
Notropis amblops	*Hybopsis amblops*
Ameiurus melas	*Ictalurus melas*
Ameiurus natalis	*Ictalurus natalis*
Ambloplites constellatus	*Ambloplites sp.*

REFERENCES

American Fisheries Society. 1991. Common and scientific names of fishes from the United States and Canada. American Fisheries Society Special Publication No. 20, Fifth Edition. Bethesda, MD. 183 pp.

Black, J. D. 1940. The distribution of the fishes of Arkansas. Unpublished PhD Dissertation. University of Michigan. 243 pp.

Cashner, R. C. and J. D. Brown. 1977. Longitudinal distribution of the fishes of the Buffalo River in northwestern Arkansas. Tulane Studies in Zoology and Botany 19:37-46.

Cashner, R. C. and R. D. Suttkus. 1977. *Ambloplites constellatus*, a new species of rock bass from the Ozark upland of Arkansas and Missouri with a review of western rock bass populations. The American Midland Naturalist 98:147-161.

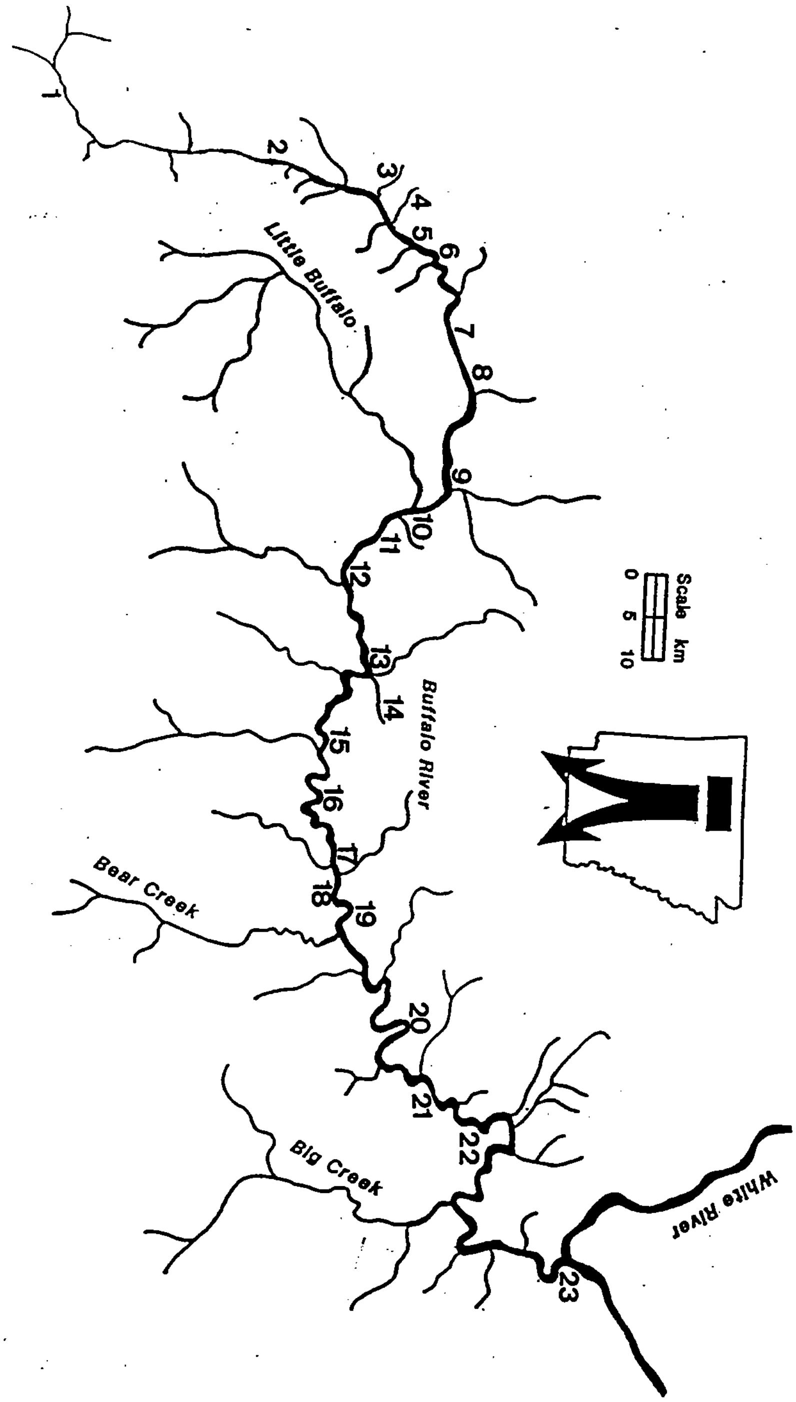
Guidroz, T. P. 1975. Fishes of the Buffalo River, White River system, Arkansas. Masters Thesis, Northeast Louisiana University, Monroe.

Kilambi, R. V. and D. A. Becker. 1977. Population dynamics and species diversity of ichthyo-parasitofauna of the Buffalo National River. Arkansas Water Resources Research Center, Publication No. 48, University of Arkansas.

Robins, C. R. and H. W. Robison. 1985. Cottus hypselurus, a new Cottid fish from the Ozark uplands, Arkansas and Missouri. The American Midland Naturalist 114:360-373.

Robison, H. W. and T. R. Buchanan. 1988. Fishes of Arkansas. University of Arkansas Press, Fayetteville. 536 pp.

Figure 1.-Fish collection sites on the Buffalo River, Arkansas: 1-near Fallsville, 2-Wilderness Boundary, 3-Clark Cr., 4-Whiteley Cr., 5-Ponca, 6-Steel Cr., 7-Kyles Landing, 8-Erbie, 9-Pruitt, 10-Little Buffalo confluence, 11-Blue Hole, 12-Carver, 13-Mt. Heresey, 14-Mitch Hill Spring, 15-Woolum, 16-White Spring, 17-Tyler Bend, 18-Shine Eye, 19-approximately 1 km below Shine Eye, 20-Maumee, 21-Buffalo Point, 22-Rush, 23-Razer Bar.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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Arkansas Cooperative Fish and Wildlife Research Unit
SCEN 617
University of Arkansas
Fayetteville, Arkansas 72701

May 13, 1993

TO: George Oviate, NPS, Buffalo National River

FROM: Jim Johnson, Leader

SUBJ: Completion Report for Buffalo National River Research Project

Enclosed in Jody Walters thesis on smallmouth bass in the Buffalo National River. This, along with the thesis by Gary Siegwarth sent to you earlier, constitutes the final report for the project funded by the National Park Service.

Just as a sidebar, Gary Siegwarth won the Best Paper award at the joint meeting of the Arkansas/Mississippi/Louisiana American Fisheries Society chapters in 1992 with his data on larval catfish movement. Jody Walters won the Best Student Paper award at the joint meeting of the Arkansas/Oklahoma chapters in 1993 with his paper on juvenile smallmouth bass habitat selection, and I won the best Professional Paper award at the same meeting with data gathered by Mr. Siegwarth on movement and survival of stocked channel catfish. All in all, I would say NPS got a lot of good publicity from this grant, as well as helping to train two excellent biologists. Gary now works for the Iowa DNR as a stream fisheries research biologist, and Jody is still job hunting. We plan to publish all of the data within the next year, and two of Gary's papers have already been submitted.

Thank you for your assistance in funding these studies and your continuing on-the-ground help to do the work. It has been much appreciated. I hope you find the information interesting and useful.

P.S. I am sending Sam Kuntle a copy directly. Many thanks to you and John Apel for all the help and advice.

Jim